Spinoza's Vermic(alc)ulus: Relativity *Sub Specie Aeternitatis*

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I. Introduction

I would like to propose that in the well-known but cryptic Letter XXXII to Henry Oldenburg, at the time the secretary of the Royal Society of London and an associate of Robert Boyle's, and which consists of an extended metaphor about "a worm in the blood", Baruch Spinoza anticipates the conceptual principle of general relativity almost three centuries before its formal elaboration by Einstein. The letter's standard reading, originating with Gilles Deleuze, takes it to be an articulation of the relationship between imagination and reason, which correspond to the whole and the part in dialectical thought, which it certainly partially is;[1] Ilaria Gaspari interprets it as a *reductio ad absurdum* in which the worm is read as a pure example of reason without imagination, and not meant to be analogous to human perception at all—a difficult position to maintain given that in the letter Spinoza states that the "little worm would live in the blood, in the same way as we live in our part of the universe"—but there is some value in this reading nonetheless, as will be seen;[2] Filip Buyse does propose a physical interpretation, related to the spontaneous synchronization of clock pendulums observed by the physicist Christiaan Huygens, one of Spinoza's associates, but reads into it only an expression of the principles of classical mechanics and claims that it represents a curious exception to the remainder of Spinoza's metaphysics;[3] Richard Mason, in one of the few Anglospheric treatments of the text, reads it as an articulation of Proposition 28 of part 1 of the *Ethics*, which states that there is necessarily an infinite chain of causes for the existence of each thing, something like a form of the prime mover argument.[4] That this letter concerns not only the internal nature of thought but also anticipates conceptually the discoveries of relativity and Noether's symmetry theorems, and furthermore is to be considered in perfect continuity with the metaphysics later formalized in the *Ethics*, will be demonstrated in the following.

The letter begins with a description of a small worm living in the circulatory system of some organism; from its perspective, this circulatory system comprises the whole universe, and it knows nothing except its constitutive corpuscules ("the lymph and chyles", one can see here the organic outgrowth of this metaphor from Spinoza's livelihood as a microscope lens grinder). Although the blood can be considered as a single fluid, the worm from its perspective can only see the movement of the individual corpuscules which constitute the blood and so takes each particles to not be merely a partial view of the greater fluid turbulence, but a self-contained object which "upon encountering another, either rebounds or communicates a part of its motion". This introduces the dialectical antinomy of the part and the whole: considering the blood as a single entity, the movement of individual corpuscules is determined by the general flow and so are not independent unities acting of themselves; and conceiving of each part as a independent unity as the worm necessarily does, ignorant of the nature of the blood, these are perceived as independent bodies that follow the laws of Cartesian mechanics. The context of the correspondence is precisely a discussion of Descartes' physical theories, as noted later in the letter; although certainly the metaphor of the worm functions, as Deleuze and Gaspari maintain, as a kind of

1 Gilles Deleuze, *Spinoza et le problème de l'expression* (Paris: Les Éditions de Minuit, 1968).
2 Ilaria Gaspari, "The Curious Case of the Vermiculus: Some Remarks on Spinoza's Letter 32 and Spinoza's Views on Imagination and Reason," *Society and Politics* 7, no. 2 (14) (November 2013).
3 Filip Buyse, "A New Reading of Spinoza's 'Letter 32' to Oldenburg," in *The Concept of Affectivity in Early Modern Philosophy* (Budapest: Elte Eötvös Kiadá, 2017).
4 Richard V. Mason, "Spinoza on the Causality of Individuals," *Journal of the History of Philosophy* 24, no. 2 (1986).

reduction to the level of immediate reason, shorn of the speculative or imaginative capacities that allow it to conceive of the whole, the point here is not merely to sketch out this antinomy, but also to analogize it to the implicit metaphysics of classical mechanics then emerging, perhaps most forcefully in Spinoza's very world of the liberal bourgeois United Provinces.[5] The description of the interaction of the corpuscules corresponds precisely to the Cartesian laws of motion under discussion at a later point in the letter. He then continues with the qualification that this is merely a metaphor: the blood is a part of the larger world, which imparts certain motions to it, and hence the movements of the blood cannot be said to result solely from its own flow. The sentences that conclude this section have been translated into English as:

> "Thus the blood comes to be regarded as a part, not as a whole. So much for the whole and the part."[6]

This mistranslation is a likely source of some of the confusion surrounding the text, at least in the Anglosphere, since it seems to foreclose the discussion of the whole and the part and demarcate the preceding metaphor from what follows. A more faithful rendering of the Latin

> "hoc modo sanguis rationem partis, non verò totius habet. De toto, & parte modò dixi."[7]

would be something to the effect of (translation mine):

> "in this way the blood is apprehended as a part, not as a whole. Of the part and the whole I have spoken of in the preceding".[8]

This refers the metaphor back to the introduction of the letter where he states his general definition of the part and the whole (translation mine):

> "By the coherence of parts, therefore, I understand nothing other than that the laws or nature of one part so accommodates itself to the laws or nature of another such that they contradict each other as little as possible. Concerning the whole and the parts, I consider things to be parts of some whole to the extent that their natures accommodate each other so that, as far as possible, they mutually agree; but insofar as they are mutually discrepant, to that extent each forms an idea distinct from the others in our mind, and consequently is considered as a whole, not as a part."

Far from foreclosing the discussion of the whole and the part, this reinscribes the blood as being a part in the part-whole dialectic. The distinction between part and whole is something that exists not intrinsically in things themselves, but in the way in which the experiential world (or extension as Spinoza calls it) is apprehended by the intellect; the corollary of Spinoza's statement that "only in relation to our imagination can things be called beautiful or deformed, ordered or confused" is that only in relation to our imagination can the distinct parts of the undivided whole be taken as unities themselves. Having first established a metaphorical system in which the blood represents the universe

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5 A brief local maximum of emancipatory thought brutally dashed by the reactionary forces of Europe; in the Orangists' cannibalism of de Witt, one can read not just a descent into animalistic brutality but into the symbolic order, reflecting perhaps a belief that ideas can be physically extirpated and bringing to mind the words of Walter Benjamin in *Theses on the Philosophy of History*: even the dead won't be safe from the enemy, if victorious. Spinoza lived a few hundred meters away from the site of the massacre and may have witnessed it personally; certainly, his philosophy should be read in juxtaposition to this tumult.

6 Benedictus de Spinoza, *Epistolae. English. Letters to Friend and Foe*, ed. Dagobert D. Runes, trans. R. H. M. Elwes (New York: Philosophical Library, 1966).

7 Baruch Spinoza, *Epistolae*, in *Opera*, ed. Carl Gebhardt, vol. 4 (Heidelberg: Carl Winters Universitaetsbuchhandlung, 1972).

8 Full translation in Appendix 1.

of the worm, this is then shown to just be another part of the total universe, another mode; Spinoza is taking what was a purely conceptual metaphor and grounding it in concrete reality, not in order to dispense with this chain of thought *tout court* as the established translation seems to assume, but to make the conceptual leap from a metaphor in which the predicate of the analysis is some particular mode of substance related to another, to the predicateless consideration of substance *qua* substance in the following section. This perspective, which anticipates and reciprocally illuminates its more rigorous formalization in Part 1 of the Ethics in the form of Spinoza's proof of the singularity of substance and its consequent infinitude and indivisibility, is necessary to fully understand this next part. Its standard English translation goes:

> "All natural bodies can and ought to be considered in the same way as we have here considered the blood, for all bodies are surrounded by others, and are mutually determined to exist and operate in a fixed and definite proportion, while the relations between motion and rest in the sum total of them, that is, in the whole universe, remain unchanged [...]"

The original Latin

> "[...] servatâ semper in omnibus simul, hoc est, in toto universo eâdem ratione motûs ad quietem [...]"

can be more faithfully translated as

> "while there is always preserved in all things at once, that is, in the whole universe, the same relation of motion to rest [...]"

"All things at once" is the literal translation of *omnibus simul*, and *ratione* is the singular form of *ratio.* These slight distinctions aren't trivial; the invariance of motion doesn't reside in the bodies themselves under the consideration of the faculty of the imagination, as Spinoza might put it, even in the form of an infinite set, but in the unitary category of "all things at once", i.e. the universe considered as a singular unfolding in its temporal dimension, though the sum total of these bodies also evidently constitutes this totality. The schema of the transition is as follows: the worm is transposed, explicitly, onto our perspective as finite subjects peering out from a corner of the universe; and the blood is transposed, explicitly, onto the concept of the universe as a whole. The metaphor is then not a meaningful demonstration purely in itself, as Gaspari holds, but is being deployed by Spinoza as a means of preparing the reader for this conceptual leap in which the important point is that we necessarily have as little a conception of the totality of the universe as the worm does of the blood, and that our experience of its modes, which seem to be self-contained, coherent wholes, are equivalent to the corpuscules seen by the worm; they are in reality part of the general flow, and only distinguishable insofar as they disagree with other parts of it. The above passage's emphasis on temporal unity refers not to specific modes but to the prior concept of substance as such, which converts the sentence from one that could be read as (merely!) one of the earliest statements of an energy conservation law in Western thought (i.e. the same amount of energy always exists in the universe) into something much more radical. Insofar as there is in every moment the preservation of the same relation of movement and rest, there exists therefore in the universe a total symmetry, and this symmetry consists of the idea that all phenomenal differentiation, the domain whose correlates are the concern of classical mechanics, is subtended by a preserved underlying unity.

This being Spinoza's intended meaning is supported firstly by the phrase that bodies are "mutually determined to exist and operate in a certain and determinate proportion" (translation mine, the existing translation substitutes "fixed" for determinate but the duplication is present in the original Latin and

fixed gives a totally different valence to the statement) being already a formulation that extends beyond classical mechanics, since here even the existence and proportion and not merely the operation of the objects is determined dynamically; secondly, from the schematic transposition of the worm metaphor by which he introduces this more abstract statement, establishing the idea of the unknowable whole; and thirdly by this underlying unity being Spinoza's preoccupation in the *Ethics* and the fundamental ground of his philosophy in general. The universe is to be conceived of as a single, flowing unity like the blood (albeit infinite) whose parts are determined according to the evolution of the whole and not only their mutual interactions, or rather these are two sides of the same unfolding, in extension and intellect, if such interactions are understood to be covariant rather than obeying the billiard ball-like motion of the sanguineous corpuscules.

That this should be the basis of a physical theory is not a particular heterodox claim, since it's more or less universally accepted that a unified theory is required to reconcile relativity and the empirical patchwork of quantum field theory, and that the ground for such a theory likely consists of a higher-order unitary generator; but what is being proposed here is that this unity is not to be found in some further elaboration of a geometric or algebraic object, but in the negative concept of unity itself (in the sense of being unencompassable by the finitude of our minds except as a negation) which is precisely the notion of Spinozist substance. That is to say that in 1665 Spinoza was already subjecting classical mechanics to the critique later completed by Einstein and Noether in the early 20th century that inverts the relative epistemic positions of univocity and phenomenal differentiation. In relativity, spacetime curvature emerges from the invariance of the speed of light; in Noether's theorems, conservation laws emerge from invariance under transformation. These are not only mathematical formalism: the unspoken common ground of all invariance is a presumed metaphysical unity. The *vermiculus* treated earlier (not antiparasitically but sympathetically, since we are no other than such a thinking worm) is a metaphorical representation of the assumptions of classical mechanics: there exist independent bodies insofar as they are grasped by us as unities in our subjective experience of the world, and through sensorial and intellectual perception (these corresponding to the attributes of extension and thought in the *Ethics)* we map the correlations of the movements to each other in their various interactions, as in Cartesian/Newtonian mechanics (or quantum mechanics for that matter, which inherits all the functional assumptions of classical mechanics under the veneer of a supposedly different ontology, insofar as its still consists of the laws of corpuscules, however vaguely defined these are). What is being proposed by Spinoza is an inversion of the part and whole; instead of macro-scale existence emerging from the aggregate of fundamental interactions, which is the (usually) unstated metaphysical ground of quantum theory, these fundamental interactions emerge instead from the relation of the part to the whole, and the evolution of a system comes about as a result of the necessary coherence of this totality, which is the metaphysical ground of general relativity and gauge symmetry, and hence this philosophical perspective is merely an excavation of the already operative logic within these.

The first objection that will be raised to the claim that Spinoza was anticipating relativity is that the latter forbids the notion of simultaneity upon which the concept of univocity necessarily depends, which is true for individual frames of reference, but from this inverted perspective of the global evolution it is exactly with respect to the coherence of *omnibus simul* that the curvature of spacetime emerges, reinscribing the notion of a shared time dimension.[9] The *a priori* postulate of univocity, or substance monism, or the singularity of substance, or the oneness of G-d (recall that the old saw goes

9 In this sense, general relativity is a misnomer, since what it recuperates from the radical decentering of all frames of reference in special relativity is in fact a general *univocity,* something alluded to by Einstein himself when he spoke of the block universe and his joke that he'd more or less reintroduced the concept of the aether to physics under the auspices of banishing it (though general relativity does roll off the tongue slightly better than diffeomorphism invariance).

"*Adonai is One"*, not "there exists only one G-d", which is a logical corollary but not so important in itself), or Tawhid, or diffeomorphism invariance etc. is the skeleton key to explaining the existence of precisely those conservation laws that had been groping towards it over the preceding centuries, and represents the unitary conservation law from which all others can be derived. To say that substance is unique and indivisible, and that modifications are prior to it, is to claim that it is invariant "in all things at once" and so the temporal differentiation that constitutes our experience of it, and of which we are composed as well, can be explained as the mechanics of the coherence of this superseding but necessarily apophatic univocity. Gravity, and acceleration in general, neither produces nor results from the curvature of spacetime, but *is* itself the curvature of spacetime in phenomenal experience. This is a fairly widely accepted implication of general relativity, but we can extend this identity even further: the causality of spacetime curvature and movement derives from the singularity of substance and its necessary invariance, rather than mass or movement itself producing the curvature; or to put it more clearly, since these represent local densifications of univocity in the mode of extension i.e. spacetime, the curvature of spacetime/acceleration comes into existence to "compensate", so to speak, for what would otherwise be contraventions of an undifferentiated univocal substance; this is the idea of symmetry under coordinate transformation but with the analytic and the unitary perspectives inverted.

This is not to say that Spinoza had formed in his mind the specific mechanism of general relativity, and in fact he rejected the idea of his perspective having any inductive power at all in the introduction of the letter,[10] but he was certainly proposing a kind of universal symmetry, a view also implied by general relativity if properly understood. This was either obscured in the analytic formalism, or failed to bear fruit as with e.g. Einstein's search in his latter years for a unified field theory. In general, the attempts in the 20th century to find a unified theory sought a unitary operator in some higher-order geometric or algebraic modification, for example as with Kaluza-Klein theory, strings, branes, twistors, loops, foams, spin networks, SO(10), etc. etc. Through the overcoming of thinking purely in terms of the modifications of substance, already dispensed with by the implications of general relativity, and instead considering, in its logical implications, the univocity of substance, that is to say to enter the once stately demesne of philosophy, now a seedy neighbourhood lying along the path to our long promised exurban idyll of purely analytic contemplation, we can attempt to lay the groundwork for a unified approach. The corollary of inverting mechanical causality for the univocity of substance monism is that any movement must necessarily consist of covariance of all things in accordance with the preservation of the commensurability of the whole, insofar as observing and motile subjects, or any other non-idealistic frames of reference, are themselves modifications of the unitary whole; therefore these local spacetime densifications of what is *a priori* an invariant unity logically require the proportional modification of the spacetime metric, which assumes the phenomenal form of acceleration and gravity. From this we can propose that the search for an independent field of quantum gravity is a metaphysical chimera already satisfied by general relativity, if properly understood in this philosophical dimension rather than as pure formalism appended to classical mechanics, and that the electromagnetic, weak and strong forces are likewise necessarily the emergent geometries of other forms of spacetime geometry, which is already latent in the Noetherian underpinnings of gauge theory; and furthermore, that the indeterminacy of quantum theory results from a series of physical and metaphysical errors. The task of this paper will be to extend the Spinozist principle of what I here term *univocal necessity* (cf. the mechanical causality of Laplace's demon the letter anticipates and critiques) to the philosophical incoherencies of certain strains of physical thinking.[11]

10 "For to know how they actually cohere, and how each part agrees with its whole—this I said in my previous letter do not know; because to know this would require knowing the whole of Nature and all its parts."

11 The preceding introduction might seem overly tendentious and repetitive, but since this is idea is so far from our intuitive experience of the world—much more closely represented by classical mechanics—such that even the austere formalism of relativity failed to imprint its revolutionary conception of things into the general imagination, and has

II. Theory

Firstly, the question that emerges logically from the preceding is that if the fundamental unit of analysis is an unchanging, undivided whole, why would there then be any motion or differentiation of spacetime at all? This was Hegel's (and Leibniz') objection to Spinozist univocity, that it collapsed all distinction into a mystical whole that foreclosed contradiction and inquiry. Spinoza's answer is found in the sentence immediately following his postulate of univocal symmetry, which also confirms that this univocal symmetry is what was being proposed just prior:

> "Hence it follows that each body, in so far as it exists as modified in a particular manner, must be considered as a part of the whole universe, as agreeing with the whole, and associated with the remaining parts. As the nature of the universe is not limited, like the nature of blood, but is absolutely infinite, its parts are by this nature of infinite power infinitely modified, and compelled to undergo infinite variations."

This is an adequate response from a theo/logical perspective, one that prefigures the strain of cosmic infinitude that seems to have permeated the consciousness of the 19th century, grasped by Boltzmann, Blanqui and Nietzsche, and which can be summed up by the énoncé of that greatest of our contemporary Spinozists, Eiichiro Oda: Everything that you can imagine exists! (*Ethics* Part 2, Prop. VII: "The order and connection of ideas is the same as the order and connection of things."). However, we are peering out from our finite instantiation of this undivided infinitude, attempting to derive a specific insight into the precise nature of the unfolding of G-d (that is to say, physics), which necessarily must exist in some local sense since *natura naturata* (nature natured) must also unspool itself according to the immanent causes of *natura naturans* (nature naturing), and not merely the abstract logical terminus of substance monism, and hence we will require something a little more specific than this statement, logically correct but ultimately lacking in any inductive power. But first, outside of the indirect empirical evidence for the univocity of existence, which has as its phenomenal form the invariance of the speed of light and consequently relativity, why should we take this postulate as the ground floor of our intellectual edifice at all? In order to proceed we can *a priori* assume the metaphysical singularity of substance according to the reasoning that Spinoza provides in Part 1 of the Ethics, which as will be demonstrated consists of a formal proof that its various detractors, such as Leibniz and Hegel, did not succeed in dispensing with, and in doing so re-derive a functional physical theory.

Spinoza's proof of the singularity of substance is as follows: firstly, he defines substance as that which is prior to its modifications. The modifications are what we take as the things of the world; substance is being defined as the negative unity of these modes. This is a proposition often cited as flawed for its circularity, given that it relies on the earlier definition of modes and substance (Defs. iii and v). However, we can derive these definitions from Axiom 1, which is a simple tautology and not a metaphysical postulate: "Everything which exists, exists either in itself or in something else." There are two possibilities here:

1) Let A be an existent, and let B be the absolute set of existents except A. In this case the axiom holds, because A cannot belong only to arbitrarily defined set C, since any such set C also belongs to B; and in

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come to be seen even by some specialists in the field merely as a metrically varying appendage to the inductive predictions of classical mechanics and quantum theory, I am "rotating the crystal", to quote Judith Butler on Walter Benjamin's writing, in an attempt to provide as many points of entry as possible to this basic idea of univocal necessity.

this case A must exist in itself and not be subsumable by any other set. So A must exist only as A, which corresponds to the definition of substance as that which is conceived of through itself. Note however that this does not preclude B from being a subset of A.

2) Let A be an existent, and let B be the absolute set of existents which contains A. In this case, the axiom holds, because A belongs to B, but A cannot belong only to arbitrarily defined set C, since any such set C belongs to B.[12]

There is an existent in the case of 1) that is, logically speaking, unitary and self contained, which corresponds to the substance of Def. iii, and there are existents in the case of 2) which are necessarily contained in something else and which corresponds to the modifications (or modes) of Def. v. However, this admits a third logical possibility not ruled out by the axiom, which I have hinted at:

3) Although in the case of 1), B can be a subset of A, there is nothing to preclude it from being a subset of another unitary and self contained existent D.

This is equivalent to the claim that there exist multiple substances, that Leibniz among others raised as an objection. This possibility can be disproven by contradiction: let us assume that there exist two substances, which we have already specified as A and D. For these to exist, they must be disjunct in terms of their modifications B or in terms of their attributes (Prop. V), which is that which the intellect perceives as the essence of a substance (Def. iv).[13] Why must A and D be disjunct? If A and D share modification or attribute X in B (i.e. B, the absolute set of existents that are not A or D, is a subset of both A and D), and A and D are therefore defined as the absolute sets that do not include themselves, then A and D are part of the Russell set, the set of sets that do not include themselves, since the number of these substances can be extended infinitely to E, F, G... As is well known, this set involves an internal contradiction (if it's part of itself, it isn't part of itself and vice-versa) and cannot exist. This leaves only the case where B is only a subset of one or neither of A or D, since in this case at least one (or infinitely many) of these substances would no longer be the absolute set that doesn't include itself but be conceived purely through itself as a free substance. This is the last remaining logical possibility, a final redoubt in Spinoza's proof, and the one corresponding to Leibniz' vision of a universe composed of monads perfectly synchronized by G-d at the beginning of time. The Russell paradox wasn't spelled out by Spinoza but implicitly undergirds Axiom V and the corresponding Props. IV and V; these are explained in a simpler, heuristic form, maybe why they've been the subject of controversy and misinterpretation: if two substances possess the same attribute or modification, they would be capable of limiting one another, and hence cannot form distinct substances. From this method also follows Leibniz' monad that allows for a multiplicity of substances that are disjunct. The set theoretic argument is included to avoid the possible confusion that what is being considered is substance as its attributes or modes—extension, thought, matter, energy and all other modifications—and not substance *qua* substance, and that this argument is a logical one as well as a physical one, i.e. the contradiction holds whether you read the heuristic argument under the attribute of extension (if substance can physically interact with another substance, then these cannot be distinct substances) or the attribute of the intellect (if you can conceive of distinct infinite substances, these must logically limit each other). I believe that Spinoza's reasoning is already by itself internally adequate with reference to the objects he describes, in

12 To the objection that Cantor has demonstrated that there exist a multiplicity of infinitudes I can only say the Cantorian notion of infinitude corresponds to that defined by Hegel as the *schlecht* infinite, that is to say the bad infinite of the endless series, which never actually escapes finitude since it consists only of an endless series of finite concepts; we are speaking here of the *echt* or the true, logical infinitude, that which is defined by the negation of the concept of the finite as such, i.e. the absolute. Those who argue that this lacks formal rigour will never be satisfied with such an idea but will have to reckon with the empirical results of this postulate nonetheless. This is not to say that the *schlecht* infinite is useless or meaningless.

13 If this notion of attribute is objectionable or vague to you, then you are of course free to conceive of things without the intellect, but for our purposes we will continue using our minds.

his Wittgensteinian private language (which he took every pain to make public), and doesn't strictly require this translation into set theoretic form; the translation is undertaken to show that the proof is correct, since this private language is only consistent if one accepts its terms. However, set theory is merely another private language that has a certain temporal validity. Let us examine the last possible remaining Leibnizian case:

4) There exist multiple substances that are disjunct and do not interact.

Spinoza immediately proceeds with a proof by contradiction that this last remaining possible case is impossible via Prop VIII. Here there is significant overlap between the set theoretic formulation and Spinoza's demonstration: if there exist multiple substances A and D that are disjunct, then each of these is necessarily infinite, since to be finite is to be limited by something which has a modification or attribute in common, and if then one substance was limited by another substance we return to the Russell paradox or the contradiction furnished by Spinoza.[14] Since each substance is infinite, and substance is that which by definition expresses existence, then substance necessarily contains the absolute set of all existents. A multiplicity of disjunct infinite substances entails a necessary overlap in their existents in the form of their attributes or modifications, in which case they are no longer disjunct; so there is only one substance.

From Spinoza's proof emerge several corollaries that will be of use in deriving a physical theory from substance monism:

Axiom 1: Uniqueness

This follows from the preceding demonstration; there can only exist a single substance.

Axiom 2: Indivisibility

This follows from the preceding demonstration and Axiom 1; to divide a substance posits the existence of a second that splits it or forms its lacuna. Spinoza derived this corollary in Prop. XIII.

Axiom 3: Inviolability

This follows from the preceding demonstration and Axioms 1 and 2; since substance is singular and indivisible, it cannot contain any disjunction, or negate or overlap itself.

Axiom 4: Locality

This follow from Axioms 1, 2 and 3. The inviolability and indivisibility of substance is the sufficient reason for the existence of locality as such, since without locality it would be in a state of universal overlap or superposition and negate itself. And so if there is a unique substance, it cannot have but a single, invariant speed of propagation. The idea of non-local correlation contravenes this, and also introduces an implicit division in the nature of substance and so cannot exist. The question of how the specific magnitude of *c* arises (which is only a measure relative to our perception in any case) is distinct from its logical requirement given the uniqueness of substance, and whose invariance emerges necessarily from its metaphysical unity.

Axiom 5: Univocity

This follows from preceding demonstration and Axioms 1, 2, 3 and 4. Insofar as there exists only a singular and therefore indivisible substance, it is impossible that could be temporal disjunction in its

14 Again in the logical sense and not the *schlecht* infinite. When Spinoza speaks of the finite and infinite he is working in the attribute of the intellect, not the attribute of extension to which the infinite series belongs (for the simple reason that this infinitude is conceivable only in time and not as a logical relation).

various parts, and considered as a whole there must exist a universal time.[15] Nor can there exist any modification within the nature of substance itself; it is prior to any phenomenon described in spacetime, which cannot contravene its underlying indivisibility and inviolability. However, from this axiom follows the idea that substance, despite being temporally univocal, is also timeless in a sense, since it contains no movement and is therefore an eternal, unchanging essence, and the changing nature of its modifications correspond to its intrinsic locality. This corresponds precisely to Spinoza's distinction of *natura naturata* (nature natured, i.e. spacetime) and *natura naturans* (nature naturing, or substance, though observe that the active principle here is attributed precisely to that which is unchanging and unobservable).

With the help of this more rigorous definition of substance in the *Ethics*, we can see more clearly what is meant by the statement "*servatâ semper in omnibus simul, hoc est, in toto universo eâdem ratione motûs ad quietem*". Substance is both unitary (it contains all apparent things) and has a temporal univocity; but at the same time, its essence is fundamentally invariant, and all its spacetime modifications unfold in such a way that its extensional univocity is preserved, such that there is in a sense no movement within it, or: the relation of motion and rest is always preserved in all things at once. This is a more or less formal definition of univocal necessity.

Axiom 6: Necessity

This follows from the preceding demonstration and Axioms 1, 2, 3, 4, and 5. If there is only a singular substance, and this substance is necessarily causally local, then all modes of substance have determinate causes within substance itself, and cannot be contingent or random. Therefore also the causes of modes are not to be found solely in their internal nature or to abstract laws of mechanics, but according to the absolute necessity of the preservation of the unity, indivisibility, inviolability, locality and univocity of substance as a whole. Spinoza derived this axiom in Props. XXVIII and XXIX.

Proposition 1: All particles and forces are necessarily excitations *of* the spacetime metric with respect the underlying, unitary substance.

Proof: this follows from Axioms 1 and 3. If substance is unique and indivisible, particles and force carriers cannot be discrete entities but must necessarily be a form of geometric excitation within it. They cannot be fundamental substances in themselves of which nature is composed, because this suffers the logical contradiction of the positing of multiple substances, nor can they be abstract point particles with internal non-spacetime dimensions, or exist in a state of contingent superposition etc. They represent the topological modifications of spacetime with respect to the invariance and indivisibility of substance.

Proposition 2: The universe cannot be discrete at a fundamental level.

Proof: this follows from Axiom 2 and Prop. 1. The idea that there exists a minimum scale of resolvability of the universe confuses the logical order of the modification of substance with the indivisible and infinite (here in the sense of the continuum) prior nature of substance. This is not to

15 Note that this isn't equivalent to saying that there exists simultaneity for different frames of reference, but that there exists simultaneity from the perspective of the whole, one from which of course we are categorically barred. This is where Gaspari's reading has some value, since the worm is in fact a *reductio ad absurdum*, though not of the imaginary capacity itself but rather the categorical impossibility of the imaginary conceiving of the absolute; we can grasp it only through negation, i.e. the prior category of substance. This responds also to Hegel's charge that in Spinoza there is only pure affirmation of the undivided whole, since substance is only conceived of through the negation of its attributes (i.e. that which the intellect takes as the essence of substance) and not as a vulgar materialism.

claim that discretization is not a feature of the observable world; on the contrary, we see at every scale of experience what seems to be an emergent discretization, from the quantum scale, to the stable forms of the elements, all the way to the cosmological scale. This emergent order is partly a refraction of the intellect grasping the parts of the undivided whole, as in the metaphor of the worm in the blood, but it is also partly because insofar as any mode exists, it exists only due to its autopoietic nature, as true for a common riverstone as for living organisms. That is to say, in Spinozist terms, that everything has its own *conatus*, a persistence in time owing to the relation of its parts, and hence everything that exists will necessarily tend towards an apparent discretization in general. The world is composed solely of time crystals, so to speak.[16] To explain the emergence of discretization at the Planck scale, there must exist a dynamic internal to the nature of substance. Consider the extremal limit of a rotating Kerr black hole, whose maximum angular momentum for a given mass is given by:

$$J_{\max} = \frac{GM^2}{c}$$

The angular momentum for a rotating object with mass M and radius R is:

$$J = I\omega \approx \frac{2}{5}MR^2\omega$$

for the approximation of a rotating black hole by a uniform sphere. The extremal condition becomes:

$$\frac{2}{5}MR^2\omega = \frac{GM^2}{c}$$

and hence the maximum angular frequency for an object with a given radius and mass such that it doesn’t collapse into a black hole is:

$$\omega_{\max} = \frac{5}{2}\frac{GM}{cR^2}$$

In order to derive the required M of the rotating object, consider that R must be equal to or greater than the Schwarzschild radius for a given M, or else this would likewise result in a black hole:

$$R_s = \frac{2GM}{c^2} \leq R$$

So the maximum mass (of interest because we are trying to derive the highest possible angular momentum before collapse) for a given radius is:

$$M_{\max} = \frac{c^2R}{2G}$$

Substitute this into the formula for the maximum angular frequency:

$$\omega = \frac{5}{2}\frac{G}{c}\cdot\frac{c^2R}{2G}\cdot\frac{1}{R^2} = \frac{5}{4}\frac{c}{R}$$

Now, consider a radius just above the Planck length, with α as a dimensionless factor:

16 In his later years David Bohm had also arrived at this conception of particles as autopoietic modes of the undivided whole, describing them as having an oscillatory, clock-like internal nature.

$$R = \alpha l_P = \alpha\sqrt{\frac{\hbar G}{c^3}}$$

Substitute the Planck length for R and evaluate:

$$\omega = \frac{5}{4}\frac{c}{\alpha\sqrt{\hbar G/c^3}} = \frac{5}{4\alpha}\sqrt{\frac{c^5}{\hbar G}}$$

This, however, is the Planck angular frequency:

$$\omega_P = \sqrt{\frac{c^5}{\hbar G}} \approx 1.85 \times 10^{43}\ \mathrm{rad/s}$$

And so the angular frequency required to form a black hole at a radius slightly above the Planck length ($\alpha > 1$) is just slightly below the Planck angular frequency, from which we can conclude (given the approximations used) that the Planck angular frequency is on the order of the extremal of Kerr black hole formation at the Planck length:

$$\omega = \frac{5}{4\alpha}\omega_P$$

Given the invariant speed of substance derived in Axiom 4, represented here by the Planck angular frequency as a massless term (that the derivation concerns a massive body is of no importance, since the goal was to extract the mass-energy relationship implicit in the Schwarzschild radius equation), at a smaller radius than the Planck length with a constant linear velocity *c*,[17] the consequent increase in the total energy density of the rotating system would result in the formation of a black hole, which logically forbids the emergence of any coherent oscillation (and which we cannot detect in any case). This can demonstrated in very simple geometric terms: if you decrease the radius of a rotation, for a given constant linear (or tangential) velocity the angular frequency must increase proportionally:

$$\omega = \tfrac{v}{R} \quad \Rightarrow \quad \omega \propto \tfrac{1}{R}$$

The total kinetic energy of a rotating sphere is:

$$E = \tfrac{1}{2}I\omega^2$$

And its moment of inertia is:

$$I = \tfrac{2}{5}MR^2$$

And so, substituting the above terms, one arrives at:

17 Though it should be noted this is a proxy for the speed of substance of which they are a modification, perhaps less confusingly represented in the propagation of gravitational waves.

$$E = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v}{R}\right)^2$$
$$E = \frac{1}{5}Mv^2$$

That is to say, given a constant tangential velocity, the total kinetic energy of a rotating sphere remains constant as you diminish its radius. However, since its volume also evidently decreases, the total energy density increases:

$$\rho_E = \frac{E}{V} = \frac{\frac{1}{5}Mv^2}{\frac{4}{3}\pi R^3}$$
$$\rho_E = \left(\frac{3Mv^2}{20\pi}\right)\frac{1}{R^3}$$
$$\rho_E \propto \frac{1}{R^3}$$

The angular frequency of the Kerr extremal scales with radius proportional to the inverse square, as demonstrated above, and energy density given constant tangential velocity scales with radius proportional to the inverse cube. And so, since the Planck angular frequency corresponds to the Kerr extremal limit at the Planck length and this relationship is already massless, if we interpret this as approximately the breakpoint of equality between these two scaling laws, some decrease in the radius of a rotation at constant tangential velocity *c* below the Planck length, given the subsequent proportionally greater increase in energy density, would result in the formation of a black hole. This heuristic derivation establishes a lower bound for any phenomenon that we can consider to be well ordered, if, following Prop. 1, we take all fundamental particles (as currently known) to be coherent, autopoietic excitations in substance without the need to consider some other field or medium in which they subsist, meaning that they must be topologically consistent with the axioms of indivisibility, inviolability and locality (and this last, Axiom 4, explains why such a lower bound exists, since the speed of substance is invariant). This may also provide (at least in the abstract) the explanation for the Mass Gap, since from the preceding any rest mass is also necessarily a geometric modification of substance and would be subject to the same lower bound (rest mass will be treated in the following). However, in accordance with the indivisibility of Axiom 1, this doesn't necessarily preclude the existence of fluctuation in substance below this threshold (and in fact the axiom of indivisibility requires an infinite continuum of fluctuations [but neither are these contingent, merely unobservable]).[18] It does however provides a candidate mechanism, derived solely from general relativity, for the quantization of fundamental excitatory phenomena, if both general relativity and the quantization of particles are understood to be inscribed in the encapsulating framework of univocal necessity.

Proposition 3: The SU(3)xSU(2)xU(1) unitary product group relates to geometric excitations of spacetime.

Preliminary Abstract: From Axiom 1, there exists a singular substance, and so these cannot represent multiple distinct substances, and insofar as substance is indivisible and inviolable, these must represent connected topological excitations. U(1) would correspond to the simplest wave like oscillation of the spacetime metric of a given worldline orthogonal to its longitudinal axis, as represented by its single complex vector and which is therefore Abelian, since a single complex rotation commutes. SU(2) corresponds to the connected rotations of the spinorial field, as the Dirac belt trick illustrates, and these

18 And so the answer to the question of what the universe was up to during the Planck "epoch" might be: not much, what's up with you?

are derived from the intersection of two rotating worldlines and therefore non-Abelian, since basis rotations are non-commutative. SU(3) corresponds to the complex spherical harmonics derived from the intersection of three worldlines and which are non-Abelian for the same reason as SU(2), from which the phenomenon of colour confinement can be explained as the fact that a standing harmonic cannot be decomposed by one of its dimensional axes and still exist; the short range of the strong force is also explainable as a consequence of this being a standing excitation and not a propagating one. An SU(2) rotation respects the symmetry of U(1) since the latter only defines its amplitude in time; an SU(3) rotation respects the symmetry of SU(2) since the harmonics are symmetric with respect to rotation, and rotations are symmetric with respect to the specific harmonic form.[19] Since oscillation, rotation, and standing resonance are the only transformations of substance that respect the geometric constraints of Axioms 2, 3 and 4, these necessarily represent the total possible forces in nature.

Corollary: The electromagnetic, weak and strong forces emerge from univocal necessity. Since, from Props. 1 and 2, any particle is a modification of substance, and since from Axiom 5 this substance is univocal, it is univocal necessity as per Axiom 6 that brings about the existence of force carrying particles, such that the local excitatory modes of spacetime, which conceived of naively would introduce variation and disjunction in the nature of substance, require their concomitant force carriers in order to preserve the indivisibility and univocity of substance. This is already encoded in the Noetherian underpinnings of gauge symmetry.

Proposition 4: Mass represents the topological knotting of a worldline along its axis.

Preliminary Abstract: U(1) force carriers have no mass because their oscillations are orthogonal to their worldline; electric charge emerges as the contraction of spacetime to preserve the univocity of all other oscillations (or phases) with the oscillations under consideration, but there is no “looping” of the worldline upon itself. SU(2) particles and force carriers contain mass because spinorial rotations loop the worldline on itself, and hence the particle “moves” slower than background substance (though the derivative of the worldline itself remains *c)*. SU(3) particles and force carriers, as standing harmonics, not only “loop” the worldline upon itself but also represent the the nodal point of constructive interference of the 3 possible rotational worldlines expressed as complex spherical harmonics, and hence contain not only much greater “mass” than SU(2) particles owing to the increased topological complexity of their worldline modification, but exist as more or less localized phenomena and not freely propagating waves like U(1).

Proposition 5: Special and general relativity emerge from univocal necessity.

Preliminary abstract: This is a restatement of general relativity, but proceeding from the top down rather than the bottom up method of the stress energy tensor: any densification or variation in the modifications of substance requires, since from Axiom 4 the speed of substance is invariant, the concomitant curvature of the spacetime metric such that the indivisibility and inviolability of substance is preserved. In the case of special relativity, consider the Rindler horizon formed behind an accelerating frame of reference; although it is correct to say that from the observer’s perspective this represents an event horizon, from the perspective of univocity there is no (and there cannot be, as per Axiom 2) disjunction in substance. And since the Lorentz transformations are the result not of

19 This also presents an intuitive reason for why the attribute of extension has 3 spatial dimensions (n.b. that Spinoza does not consider this attribute to be the totality of G-d’s existence as per the hackneyed accusation of pantheism, merely the one we exist through): 2 spatial dimensions are insufficient for the existence of this topological “knotting” of substance while preserving indivisibility and inviolability, and 4 are too many.

acceleration in itself as a free mechanical cause but are (as has been stated) co-identical with it, the modification of the spacetime metric results from the logical postulate of the indivisibility of substance, such that the speed of light remains invariant for all frames of reference. This is what Spinoza meant by the unchanging relations of motion and rest, since although a given frame of reference is perhaps accelerating from the perspective of another, in the nature of substance itself the Lorentz transformations result in there being no movement, the inverted corollary of the invariance of *c*. In the case of general relativity, any rest mass, as per Props. 1, 3, and 4, consists of a spacetime modification of the univocity of substance along the longitudinal axis of a worldline, that is to say that it is at rest with respect to *c* only because of the topological nature of its excitations; if you unrolled these, so to speak, you would derive a constant worldline velocity *c*, whose line integral would be proportional to the stress-energy tensor. From the postulate of univocal necessity (Axioms 5 and 6) that preserves the locality (Axiom 4) and indivisibility (Axiom 2) of substance results the corresponding curvature of spacetime when the sum total of these modifications are considered with respect to a frame of reference. Another way to put this is that any such densification of spacetime would, without the complementary curvature, contravene the underlying unity of the substance which not only serves as its abstract space of subsistence but which constitutes it.

III. Results

I freely admit that the above contradicts more or less the entire orthodoxy of physics, and if I were to assume the position of some mental magistrate and qualify myself as anything at all, it would be as a philosopher and not a physicist; but as Feyerabend never said, the proof is in the plum pudding model. To claim that the universe is local, non-discrete and that indeterminacy is only an epistemic perspective, however well logically grounded, contradicts a number of well known results. However, instead of reading the following as a Procrustean massage of those results to fit them into the pre-established, ideal theory, the genesis of this paper lay on the contrary in the contemplation of these apparent paradoxes of physics, with the ideas of superposition/non-local correlation principal among them; and so their contemplation and resolution preceded and spurred the above theory, temporally and conceptually, and not the other way around.

Non-Bohmian Pilot Wave, Bell Equality and Entanglement

We have derived the logical impossibility of nonlocality in the preceding Axiom 4, which brings us headlong into conflict with Bell's theorem, perhaps the most exhaustively verified result in modern physics. This is not to claim that there is any mistake in the experimental verifications of Aspect and Zeilinger among others, nor that there is an error in Bell's derivation. However, there is, as with von Neumann's earlier proof of non-locality, a flawed assumption contained in the posing of the question itself. The often elided fact that Bell was himself a believer in Bohmian mechanics explains why such a question had to be posed; rather than being a pillar of support for the Copenhagen interpretation, as frequently been portrayed, Bell was attempting to buttress the position of non-local *hidden variable* theories, of which Bohmian mechanics precisely is one. This nonlocality emerged as an artefact of the time-foliation approach inherent in the Schrödinger equation adapted by Bohm to articulate his vision, since there being no definite, classical trajectory to a particle, the evolution of the system has to be considered *de novo* at every moment*;* and likely also as a result of the general belief in the impossibility of local hidden variables even prior to Bell's theorem, owing to Grete Hermann's 1936 critique of von Neumann's 1932 no-go theorem not being widely known until Bell himself rediscovered it decades later. However, if there indeed exists a definite history to this trajectory and the associated wave (as a real physical phenomenon and not merely an abstraction, which therefore also corresponds perhaps to Feynman's path integrals) then this nonlocality is unnecessary. That the

Copenhagen interpretation and the standard quantum formalism represents a metaphysical absurdity follows from the logic of the derivation of substance monism, and which emerged, in my opinion, largely from the misapprehension of the double slit experiment. Instead of diving into the weeds and attempting to show this immanently, it will be simpler to provide a coherent alternative hypothesis, one that dispels both the cumbersome nonlocality of Bohmian mechanics and the idealism of the Copenhagen interpretation, while in a sense representing a unification of their respective one-sided epistemic positions.

Consider a pair of photons entangled in the singlet state; rather than reproducing the quantum notation, which exists to account for the assumed indeterminacy, we will assume that this spin entanglement consists simply of a correlated polarization phase. We will also assume a pilot wave model, but one that is classical rather than Bohmian; that is to say that the polarization phase is the property of a wave that exists concretely in spacetime, and there exists at some unknown (but definite) position within this wave a photon. If you assume that in the process of spontaneous parametric down conversion these waves acquire opposite helicities, then the summed correlations observed in experimental verifications of the Bell inequality correspond in magnitude to those predicted by Malus' Law for the intensity of a classical wave that passes through a polarizer, from the perfect anti-correlation when measured along the axis of the wave trajectory to perfect correlation at 180 degrees (but in reality seeing the same helicity at this angle), with the probabilistic chance of detection at any phase angle attributable to the assumption that the particle has an equally distributed chance of occupying a definite position in the phase at the moment of measurement and hence being carried through by the pilot wave or not. Consider the proportion of a wave's intensity that will transmit through a polarizer according to the classical prediction at a polarizer offset of 22.5° from the direction of travel:

$$I = I_0 \cos^2 \theta$$

$$\cos^2(22.5^\circ) \approx 0.854$$

This corresponds precisely to the quantum mechanical prediction for the probability of a given spin measurement at the same offset, and all remaining offsets are equal to those predicted by the standard quantum mechanical model. The mechanism being proposed for the hidden variable is that there exists a realist pilot wave, similar to the Bohmian formulation but dispensing with nonlocality, the proportion of which passes through the polarizer obeys Malus' Law, and since the concrete (if unknowable) trajectory of the particle is determined by the pilot wave, its probability of measuring spin "up" or "down" as indexed by its passage through the polarizer is probabilistic and not intrinsic. How then to reconcile this with the seemingly hermetic inequality derived by Bell? There is, in the proof of the classical CHSH upper bound of S <=2, an implicit assumption that that the probability distribution ρ(λ) is equal for all choices of measurement A, a, B and b, that is to say the assumption of Measurement Independence (eliding the full derivation):

$$S = |E(A,B) + E(A,b) + E(a,B) - E(a,b)|$$

$$S = |\int \rho(\lambda)[A(\lambda)B(\lambda) + A(\lambda)b(\lambda) + a(\lambda)B(\lambda) - a(\lambda)b(\lambda)]d\lambda|$$

$$S <= 2$$

This is a logical assumption if the hidden variables are presumed to be truly predetermined, or if any measurement dependence is assumed to violate the Specken-Kocher theorem; however, in the theoretically possible model elaborated above, the hidden variable is not simply a pre-existing distribution but results from the combination of *both* the hidden variable, i.e. the particle's position in

the pilot wave's phase, and the chosen measurement angle; that is, each measurement offset angle generates its own probability distribution according to Malus' Law, and this probability neither exists entirely in the "hidden variable" nor the measurement choice alone; it then follows that the above reverts to:

$$S = |\int \rho(\lambda|A,B)A(\lambda)B(\lambda)d\lambda + \int \rho(\lambda|A,b)A(\lambda)b(\lambda)d\lambda + \ldots|$$

Under this assumption, the upper classical correlation limit would no longer be 2 but precisely Tsirelson's bound when at the maximum excedence of the CHSH bound for spin-1 particles (A = 0°, a = 45°, B = 22.5°, b = -22.5°):

$$S = |((1 - cos^2(A-B)) - cos^2(A-B)) + ((1 - cos^2(A-b)) - cos^2(A-b)) \ldots|$$

$$S = |-cos(2(A-B)) - cos(2(A-b)) - cos(2(a-B)) + cos(2(a-b))|$$

$$S \approx 2.828$$

This should be no surprise since the math is likewise identical, sans the assumption of superposition; the only surprising thing is that this possibility was never considered by Bell himself, since it's a combination of classical electromagnetism with pilot wave theory and he was a staunch Bohmian/pilot wave advocate. What is being posited is that the hidden variable is not a static property of the particle, but the dynamic combination of the a) the pilot wave's phase, a concrete spacetime modification of substance, and the particle's position therein, and b) the choice of measurement offset angle, and its resulting probability distribution arising from the proportion of the wave transmitted through the polarizer according to Malus' Law.

For spin-1/2 particles like the electrons Bohm originally considered, the twisted-belt topology of the SU(2) group, as a concrete spinorial worldline "knot" in substance as per Prop. 3, a spatial rotation of θ corresponds to a phase rotation of θ/2 rather than θ. The fundamental mechanism that produces a probabilistic local contextual measurement dependence is similar to that of the bosonic case, in that the spinorial pilot wave is split by the Stern-Gerlach magnets and the position of the fermionic particle itself (also a spinor) in this wave determines whether it follows the "spin up" or "spin down" measurement. This is equivalent to Bohm's model of the experiment, where the wavefunction branches guide the concrete particle trajectory to respective "spin up" and "spin down" measurements, and these reflect a property of the pilot wave and the particle's position and not some intrinsic quality of the particle itself.[20] Bohm however assumes the Born rule *a priori* as a way of explaining the probability density of the particle's position, inherited from the quantum formalism. If we perform the same Spinozist surgery as before and assume that the pilot wave is a real wave and not a non-local mathematical abstraction in category space,[21] the probability of the particle being in the "spin up" branch is determined by the geometric projection of the spinorial pilot wave's phase onto the measurement axis. However, this cannot be derived by simply transposing Malus' Law; we can derive an analogous mechanism that can theoretically reproduce the same distribution in the fermionic case,

20 David Bohm & Basil Hiley, *The Undivided Universe* (1993). London: Routledge, 1993.

21 That the wavefunction consists of a real, time-dependent wave phenomenon was incidentally proven to be true by Mahler et al. (2016), who in the process of responding to the surreal paths objection to Bohmian mechanics showed that the position/time of the measurement affects the resulting interference pattern.

and within the experimental setup of the Stern-Gerlach apparatus in particular. For photons, the polarizer transmits only the component of the field vector E parallel to its transmission/measurement axis; for electrons, the Stern-Gerlach magnet acts analogously as a "spin filter", imposing a boundary condition defined by the magnetic field gradient B (the measurement axis), and the interaction Hamiltonian $H \propto \sigma \cdot B$ splits the wave into two branches aligned with this field axis. Here, σ represents the orientation of the spinorial "knot" in spacetime and not in Hilbert space, which can be reinterpreted as an abstract mapping of this real space; because the wave is a spinorial excitation, it admits only two stable orientations relative to the field (as the double cover of SO(3)). Assuming the particle's concrete position has an equal probability distribution across the wave, and this wave is a modification in substance of the spacetime metric itself, the probability of finding the particle in a specific branch is proportional to the wave's spacetime metric density, homologous to the energy density. This density scales with the squared modulus of the spinor's projection onto the measurement axis:

$$P = | \langle \uparrow \theta \mid \psi \rangle \mid 2 = cos^2(\theta/2)$$

This is a geometric re-statement of the Born rule, and in a sense an extension of Malus' Law to the spinorial case. It likewise produces the Tsirelson bound at maximum excedence of the "inequality", at double the measurement offset angles of those above, and reproduces the standard QM correlations for spin-1/2 particles. So the resolution of the EPR Paradox, which seems to show that one of either the philosophically incoherent assumptions of the Copenhagen interpretation or the philosophically incoherent conclusions of Bohmian mechanics are correct, consists of the fact that there exists both a pilot wave with hidden variables as per Bohmian mechanics *and* a measurement effect as per the Copenhagen interpretation, and this combined effect of the measurement and hidden variable is explicable in purely classical terms without lugging along either the metaphysical baggage of indeterminacy and superposition or nonlocality. This is distinct from the superdeterministic interpretation, where the universe conspires to produce the correlations (and if I may add, this is a trivial conception of determinism, since although the world unfolds in a unique and necessary way, when we speak of correlations we're necessarily already speaking of the relations between modes, and not between these and the totality). Rather, the outcome is determined by a local interaction determined at the moment of measurement itself, while the correlation is nevertheless global. This is not in itself a full derivation of a realist pilot wave theory, but it is sufficient to demonstrate that Bell's theorem does not apply to this theoretically possible model as it violates the assumption of measurement independence while preserving contextuality.

Double Slit Experiment

As Richard Feynman said, the double slit contains within it all the mysteries of quantum mechanics; a slightly less charitable reading would be that it contains all its confusions as well. The Bohmian/generic pilot wave perspective has already provided a resolution to its seeming paradoxes, one that is coherent with the idea of univocal necessity; if particles are oscillatory excitations of the spacetime metric, then they are not isolated corpuscules but necessarily part of a larger wave system that exists concretely in spacetime and not just in abstraction;[22] in the Bohmian version of the double slit, there is at once a particle and a pilot wave that guides the movement of the particle, and so reproduces in its time-series evolution the probability distribution of the Schrödinger equation, with the difference that at every moment the particle occupies a definite position in this probability space. When the path the particle takes through the slits is unmeasured, the position of the particle on the screen forms an interference

22 As demonstrated empirically in the analogous reduction by Y. Couder et. al: "Dynamical phenomena – Walking and orbiting droplets", *Nature* 437 (2005), no. 7056, p. 208. This also might provide a concrete mechanism for the autopoietic emergence of particles that I only have the tools to describe in the abstract.

pattern corresponding to the diffraction of this pilot wave; when, however, the particle is measured, this wave, consisting of the fluctuation of spacetime around a coherently oscillating particle (which is also a fluctuation of spacetime), is disrupted by the measurement, not because of any privileged effect of consciousness, information, subject etc. but for the simple reason that any measurement we can make will categorically disrupt this sub-particular wave system: even if this measurement were to be as non-intrusive as a single photon, this is nonetheless a coherent oscillation with its own wave system. By analogy this is like trying to determine, from its waves alone, the trajectory of a loon swimming in a placid Laurentian lake from the deck of a moving oil tanker-*cum*-wildlife research vessel. The delayed choice quantum eraser,[23] which purports to eliminate this possible source of interference, has been shown by Sabine Hossenfelder to be an artefact of the experimental setup: the interference patterns of the idler photons of measurements D3 and D4, taken to be evidence of a "delayed choice" entanglement effect, are merely the result of the phase shift selectively introduced by the beam splitters themselves, which are then manually extracted from the always uninterfered pattern of the signal photons, a pattern that can also be recovered by simply summing the respective interference patterns of D3 and D4 (since they are phase shifted relative to one another, something that can also be seen in their mirror asymmetries), and so not at all analogous to the wave interference of the double slit. The mechanism is similar to that of the Bell inequality treated above: there exists a definite position of the photon in a realist pilot wave, which combined with the phase-dependent action of the beam splitters creates the observable "interference".

Aharonov-Bohm Effect and the Vector Potential as Spacetime Oscillation

[Forthcoming]

IV. Conclusion

Given that this theory is more or less just a reinterpretation of the existing formalism and observations to make them consistent with the necessity of substance monism, *j'ignore* if it has any practical applications. My purpose in following this line of inquiry was only to show that things are at once very simple and irreducibly deep; as Alain Badiou says, the difficulty of mathematics is that they are in a sense *too* simple (n.b. not easy or facile) relative to the sinuous panoply of existence. While the assumed multiplicities of physics finish by reproducing the world in the image of Benjamin's homogeneous empty time, the reduction to univocity of our understanding paradoxically brings us back to the multitude of the world in its unique unfolding, and reorients us to its intellectual and ethical demands. It is this reversal in philosophical thinking that marks the transition from classical to modern physics, already articulated more or less explicitly by the early 20th c. developments of general relativity and Noether's work on invariance, and not the contemporaneous conjuration of the realm of quantum indeterminacy and nonlocality. Whether or not Spinoza erred in stating the impossibility of deriving a unified theory, since according to him such a thing would require knowledge of the totality of Nature, consider that his metaphysical vision, which at the very least must be confronted by any physicist as a formal challenge to the *prima facie* existence of fundamental multiplicity, forms only the succinctly established foundation for the derivation of his ethical and political thinking; and since this foundation is inseparable from the ethics and political thinking it entails, then I hope there will be some value in staging this philosophical intervention.

23 Kim et al., "A Delayed 'Choice' Quantum Eraser," *Physical Review Letters 84, no. 1 (2000): p.* 1–5.

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Appendix 1

LETTER XXXII
To the most Noble and most Learned Man, Henry Oldenburg, from B. D. S.
Reply to the Preceding

Most Noble Sir,

That you and the most Noble Mr. Boyle kindly encourage me to philosophize, I give the greatest thanks; I indeed, as far as the slightness of my talent allows, proceed as much as I can, meanwhile not doubting your help and benevolence.

When you ask what I think concerning the question which turns on this: that we may know how each part of Nature agrees with its whole, and in what way it coheres with the others, I think you are asking for the reasons by which we are persuaded that each part of Nature agrees with its whole and coheres with the rest. For to know how they actually cohere, and how each part agrees with its whole—this I said in my previous letter I do not know; because to know this would require knowing the whole of Nature and all its parts.

I shall therefore attempt to show the reason which compels me to affirm this; yet first I wish to warn that I do not attribute to Nature beauty, deformity, order, or confusion. For things cannot be called beautiful or deformed, ordered or confused, except with respect to our imagination.

By the coherence of parts, therefore, I understand nothing other than that the laws or nature of one part so accommodates itself to the laws or nature of another that contradict each other as little as possible. Concerning the whole and the parts, I consider things insofar as they are parts of some whole to the extent that their natures accommodate each other so that, as far as possible, they mutually agree; but insofar as they are mutually discrepant, to that extent each forms an idea distinct from the others in our mind, and consequently is considered as a whole, not as a part.

For example, when the motions of the particles of lymph, chyle, etc., mutually accommodate each other in proportion to their size and figure so that they are plainly in mutual agreement and all together constitute one fluid, to that extent only are chyle, lymph, etc., considered as parts of the blood; but insofar as we conceive the lymphatic particles to differ from the particles of chyle in respect of figure and motion, to that extent we consider them as a whole, not as a part.

Let us now imagine, if you please, a little worm living in the blood, which is capable of distinguishing by sight the particles of blood, lymph, etc., and by reason of observing how each particle, upon encountering another, either rebounds or communicates a part of its motion, etc. That worm would indeed live in this blood as we live in this part of the universe, and would consider each particle of blood as a whole, not as a part, nor could it know how all the parts are moderated by the universal nature of blood and are compelled to accommodate themselves to one another, as the universal nature of blood demands, so that they mutually agree in a certain proportion.

For if we imagine that there are no causes external to the blood which would communicate new motions to the blood, and no space external to the blood, nor any other bodies into which the particles of blood could transfer their motion, it is certain that the blood would always remain in its state and its particles would undergo no other variations than those which can be conceived from the given relation of the motion of blood to lymph, chyle, etc. And thus the blood would always have to be considered as a whole, not as a part.

But because very many other causes exist, which moderate the laws of the nature of blood in a certain way, and are in turn moderated by the blood, hence it happens that other motions and other variations arise in the blood, which follow not solely from the relation of the motion of its parts to each other, but

from the relation of the motion of the blood *and* of the external causes to each other simultaneously. In this way the blood is apprehended as a part, not as a whole. Of the part and the whole I have spoken of in the preceding.

Now since all bodies of Nature can and must be conceived in the same way as we have here conceived the blood—for all bodies are surrounded by others, and are mutually determined by each other to exist and to operate in a certain and determinate proportion, while there is always preserved in all things at once, that is, in the whole universe, the same relation of motion to rest—it follows from this that every body, insofar as it exists modified in a certain way, must be considered as a part of the whole universe, must agree with its whole, and must cohere with the others; and since the nature of the universe is not limited, like the nature of blood, but is absolutely infinite, therefore its parts are moderated by this nature of infinite power in infinite ways, and are compelled to undergo infinite variations.

But with respect to Substance, I conceive that each part has a closer union with its whole. For as I formerly attempted to demonstrate in my first letter, which I wrote to you while still living at Rijnsburg, since it is of the nature of Substance to be infinite, it follows that each part pertains to the nature of corporeal Substance, and can neither be nor be conceived without it.

You see, therefore, in what way and why I hold that the human Body is a part of Nature. As for the human Mind, I also hold that it is a part of Nature; namely because I maintain that there exists in Nature an infinite power of thinking, which, insofar as it is infinite, contains within itself objectively the whole of Nature, and whose thoughts proceed in the same way as Nature—that is, as its ideal correlate.

Next, I hold that the human Mind is this same power, not insofar as it is infinite and perceives the whole of Nature, but insofar as it is finite, namely insofar as it perceives only the human Body. In this way I hold that the human Mind is a part of a certain infinite intellect.

But to explain and demonstrate all these things accurately here, along with what is connected to this matter, would be too lengthy a task, nor do I think you expect this from me at present. Indeed, I doubt whether I have sufficiently grasped your meaning, and whether I have answered something other than what you asked—which I would like to know from you.

As for what you then write, that I hinted that almost all of Descartes' rules of motion are false: if I remember correctly, I said that Mr. Huygens thought this, and I affirmed that no other rule is false except Descartes' sixth rule, regarding which I said I thought both Huygens and Descartes were in error. On this occasion I asked you to communicate to me the experiment which you performed in your Royal Society according to that hypothesis; but I judge that you are not permitted to do so, since you say nothing in reply about this.

The said Huygens has been and still is entirely occupied with polishing dioptric lenses. For this purpose he has constructed a machine, quite a fine one, in which he can also turn grinding dishes. But what he has achieved with it I do not yet know, nor, to tell the truth, do I greatly wish to know. For experience has sufficiently taught me that spherical lenses are polished more safely and better by free hand than by any machine. Concerning the success of the pendulums and the time of his departure for France, I cannot yet write anything certain. [...]

Voorburg, 20 November 1665.
With all affection, yours,
B. de Spinoza.

Appendix 2

Only in the future will it be possible to understand the *Tzimtzum* that brought the "Empty Space" into being, for we have to say of it two contradictory things ... the Empty Space came about through the *Tzimtzum*, where, as it were, He 'limited' His G-dliness and contracted it from there, and it is as though in that place there is no G-dliness ... the absolute truth is that G-dliness must nevertheless be present there, for certainly nothing can exist without His giving it life.

—*Likkutei Moharan, I, 64:1*